

## ***Interactive comment on “Evidence for the non-influence of salinity variability on the coral Sr / Ca paleothermometer” by M. Moreau et al.***

### **Anonymous Referee #3**

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The paper under review reports on the coral Sr/Ca proxy as indicator of temperature with no influence from salinity. The pioneering work of Weber (1973) documented the temperature dependence of Sr incorporation in coral skeletal aragonite. That study further demonstrated other factors that may influence coral Sr including water depth, species, and physiological processes the latter of which that may be influenced by salinity. Since that study, the possibility of a salinity influence on coral Sr/Ca has been investigated (Ourbak et al., 2006; Shen et al., 2005; Sinclair et al., 1998; Stephans et al., 2004; Swart, 1981) but no evidence has been found to suggest such an influence. Similar to Weber 1973, the paper under review examines several published coral Sr/Ca records for various coral species from several locations in the tropical oceans and finds no evidence for a salinity influence on coral Sr/Ca. This result is not surprising to paleoclimatologists who specialize in coral-based reconstructions; they have long

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recognized that coral Sr/Ca has a high correlation with sea surface temperature (SST) (Corrège, 2006). This is not the case for the calcite skeletons of foraminifera and their inclusive Mg/Ca variations. Furthermore, coral-based paleoclimatologists have long recognized (Weber and Woodhead, 1972) that coral oxygen isotopes vary with SST and the oxygen isotopic composition of seawater, which varies with freshwater input from terrestrial sources, ocean advection, and evaporation and precipitation thus sea surface salinity (SSS). Many studies have leverage the two coral proxies, Sr/Ca and  $\delta^{18}\text{O}$ , to reconstruct SSS by removing the Sr/Ca-SST component from  $\delta^{18}\text{O}$  (Calvo et al., 2007; Gagan et al., 1998; Giry et al., 2012; Hendy et al., 2002; McCulloch et al., 1994; Nurhati et al., 2009; Ren et al., 2002; Wu et al., 2013). One huge complication in reconstructing SSS is the lack of long instrumental in situ SSS records for comparing coral geochemical records for calibration and verification. One such location that has a long SSS record is Amedee Island in New Caledonia and several studies from that site have not found a salinity influence on coral Sr/Ca (Ourbak et al., 2006; Quinn and Sampson, 2002; Stephans et al., 2004). This lack of SSS records for testing salinity's influence on coral geochemistry has left some to question the influence of SSS on coral Sr/Ca paleothermometer but to say it is "highly debated" (page 1785, line 23) is unfounded and that statement is not supported with references.

Overall, the paper is well-written albeit brief in its discussion and data analysis. The approach the authors take is similar to that of Weber (1973) by examining coral Sr/Ca and SSS for a larger geographical area, an approach not used since that first study. Yet, several scientific issues need to be addressed.

1) The authors group several different coral genera together in their analysis. The study of Weber (1973) demonstrated that different coral species in the same environmental setting have different Sr values thus different Sr/Ca values. That conclusion was confirmed by the study of Delong et al. (2011) in their comparison of the species *Siderastrea siderea* and *Montastraea faveolata* (see table 1 in Delong 2011 for a list of other interspecies comparisons). For these reasons, the authors should not group

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all coral species together in their analysis. Yet, it is interesting that they included both coral species from Delong (2011) in their analysis. They should focus on just *Porites* since most of their records are that genera.

2) The salinity data set the authors choose to use was SODA, a reanalysis product, not actual salinity measurements. Granted, there are very few SSS records to do this analysis but can the authors really trust SODA to correspond to salinity variations on a coral reef? There are SSS records, such as the ones from New Caledonia and the ship of opportunity measurements compiled by Thierry Delcroix (1993; 2011) that can be used for comparison with SODA. I suggest the authors first start reef scale with Amedee island/New Caledonia and Clipperton Atoll, then scale up to western Pacific with Delcroix's data set, and then SODA to see how each SSS data set and coral regional grouping perform. Then assess how well SODA is capturing SSS variations compared to local and regional observations. There are other reanalysis products for SSS including NOAA NCEP EMC CMB Pacific monthly salinity (Behringer, 1998) at <http://iridl.ldeo.columbia.edu/SOURCES/.NOAA/.NCEP/.EMC/.CMB/.Pacific/.monthly/.sal>. Local SSS data may be found at <http://www.nodc.noaa.gov/General/salinity.html> and look for studies that reconstruct SSS from  $\delta^{18}\text{O}$  as a comparison and for instrumental SSS data.

3) What were the selection criteria for your coral Sr/Ca records? The authors could have included many more coral Sr/Ca records from NOAA paleoclimate as well as PANGAEA (<http://www.pangaea.de/>). If you are limited to just monthly resolved records, why? Since you are examining a wide geographical range and thus a larger range of salinities, then you can include annual and 5-year resolved records and look at mean values. To test this you can scale from monthly to annual to 5-year, and so on. If there is a relationship in *Porites* between Sr/Ca and SSS it should be apparent no matter the resolution.

4) The examination of residuals from removing the SST from coral Sr/Ca is not a necessary step. If the correlation between coral Sr/Ca and SSS is low and not significant,

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then why would you expect a relationship in the residuals? Please perform a correlation analysis between coral Sr/Ca and SSS before looking at the residuals and add a table with these correlations. Furthermore, examine the residuals; if they are white noise, then there is nothing there. Do not expect the coral Sr/Ca-SST relationship to be perfect ( $R^2=1$ ), it is impossible to perfectly extract a time series of SST from the coral for a variety of reasons.

5) The use of the average coral Sr/Ca-SST slope from Correge (2006) is odd, especially for the different coral species, for the reasons given on page 1788. If the authors feel this is necessary, then they should scale up from the local or study derived calibration with SST and then use the average SST but for just Porites, different species have different calibration slopes. Regardless, if item 4) above results in low correlations between coral Sr/Ca and SSS then why even look at the residuals from removing the SST from coral Sr/Ca?

6) The SST data set used for analysis stated as OISST in the text but Figure 1 and 2 WOA SST data. The SODA reanalysis has SST as a product as well as SSS. It would be interesting to see how SODA SST performs compared to OISST and then make your SSS assessment with SODA SSS.

Below are other items to be addressed:

Page 1784 line 21 Please provide references for this first sentence and the other sentences that follow. Use references to tell the reader which studies are you referring to.

Page 1785 line 24 Please give citations for the studies that are debating a salinity influence in coral Sr/Ca.

Page 1790 line 29 For the Gulf of Mexico records, there are local SSS measurements by NOAA buoys at the site of these corals (Maupin et al., 2008). It would be another place to compare with the SODA SSS.

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Figure 1 Use the same SSS data set that you are making your analysis with, not the a WOA which is averages. Better yet, have two panels, one with the Delcroix SSS data and the other as SODA.

Figure 2 Color code the data for the different regions, Red Sea, Indian Ocean, etc. Remove the Mg/Ca since that is not your work.

Figure 3 These graphs are confusing. You are plotting coral Sr/Ca (x-axis) against coral Sr/Ca derived from an equation based on those same data? What is independent and dependent variables? This is circular. It would be better to plot the residuals of the calibration to show what is not explained by your equations.

References Cited: Behringer, D. W., M. Ji, and A. Leetmaa, 1998: An Improved coupled model for ENSO prediction and implications for ocean initialization. Part I: The ocean data assimilation system. *Mon. Wea. Rev.*, 126, 1013-1021. Calvo, E., Marshall, J.F., Pelejero, C., McCulloch, M.T., Gagan, M.K., Lough, J.M., 2007. Interdecadal climate variability in the Coral Sea since 1708 A.D. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* 248, 190-201. Corrège, T., 2006. Sea surface temperature and salinity reconstruction from coral geochemical tracers. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* 232, 408-428. DeLong, K.L., Flannery, J.A., Maupin, C.R., Poore, R.Z., Quinn, T.M., 2011. A coral Sr/Ca calibration and replication study of two massive corals from the Gulf of Mexico. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* 307, 117-128. Gagan, M.K., Ayliffe, L.K., Hopley, D., Cali, J.A., Mortimer, G.E., Chappell, J., McCulloch, M.T., Head, M.J., 1998. Temperature and surface-ocean water balance of the mid-Holocene tropical western Pacific. *Science* 279, 1014-1018. Giry, C., Felis, T., K<sub>v</sub>∂lling, M., Scholz, D., Wei, W., Lohmann, G., Scheffers, S., 2012. Mid- to late Holocene changes in tropical Atlantic temperature seasonality and interannual to multidecadal variability documented in southern Caribbean corals. *Earth Planet. Sci. Lett.* 331-332, 187-200. Hendy, E.J., Gagan, M.K., Alibert, C.A., McCulloch, M.T., Lough, J.M., Isdale, P.J., 2002. Abrupt decrease in tropical Pacific sea surface salinity at end of Little Ice Age. *Science* 295, 1511-1514. Maupin, C.R., Quinn, T.M., Halley, R.B., 2008. Extracting

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a climate signal from the skeletal geochemistry of the Caribbean coral *Siderastrea siderea*. *Geochem. Geophys. Geosyst.* 9, Q12012. McCulloch, M.T., Gagan, M.K., Mortimer, G.E., Chivas, A.R., Isdale, P.J., 1994. A high-resolution Sr/Ca and  $\delta^{18}\text{O}$  coral record from the Great Barrier Reef, Australia, and the 1982-83 El Niño. *Geochim. Cosmochim. Acta* 58, 2754-2754. Nurhati, I.S., Cobb, K.M., Charles, C.D., Dunbar, R.B., 2009. Late 20th century warming and freshening in the central tropical Pacific. *Geophys. Res. Lett.* 36. Ourbak, T., Corrège, T., Malaizé, B., Le Cornec, F., Charlier, K., Peypouquet, J.P., 2006. A high-resolution investigation of temperature, salinity, and upwelling activity proxies in corals. *Geochem. Geophys. Geosyst.* 7, Q03013. Quinn, T.M., Sampson, D.E., 2002. A multiproxy approach to reconstructing sea surface conditions using coral skeleton geochemistry. *Paleoceanography* 17, 1062. Ren, L., Linsley, B.K., Wellington, G.M., Schrag, D.P., Hoegh-Guldberg, O., 2002. Deconvolving the  $\delta^{18}\text{O}$  seawater component from subseasonal coral  $\delta^{18}\text{O}$  and Sr/Ca at Rarotonga in the southwestern subtropical Pacific for the period 1726 to 1997. *Geochim. Cosmochim. Acta* 67, 1609-1621. Shen, C.-C., Lee, T., Liu, K.-K., Hsu, H.-H., Edwards, R.L., Wang, C.-H., Lee, M.-Y., Chen, Y.-G., Lee, H.-J., Sun, H.-T., 2005. An evaluation of quantitative reconstruction of past precipitation records using coral skeletal Sr/Ca and  $\delta^{18}\text{O}$  data. *Earth Planet. Sci. Lett.* 237, 370. Sinclair, D.J., Kinsley, L.P.J., McCulloch, M.T., 1998. High resolution analysis of trace elements in corals by laser ablation ICP-MS. *Geochim. Cosmochim. Acta* 62, 1889. Stephans, C., Quinn, T.M., Taylor, F.W., Corrège, T., 2004. Assessing the reproducibility of coral-based climate records. *Geophys. Res. Lett.* 31, L18210. Swart, P.K., 1981. The strontium, magnesium and sodium composition of recent scleractinian coral skeletons as standards for palaeoenvironmental analysis. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* 34, 115. Weber, J.N., 1973. Incorporation of strontium into reef coral skeletal carbonate. *Geochim. Cosmochim. Acta* 37, 2173-2190. Weber, J.N., Woodhead, P.M., 1972. Temperature dependence of oxygen-18 concentration in reef coral carbonates. *J. Geophys. Res.* 77, 463-473. Wu, H.C., Linsley, B.K., Dassié, E.P., Schiraldi, B., deMenocal, P.B., 2013. Oceanographic variability in the South Pacific Convergence Zone region over the last

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210 years from multi-site coral Sr/Ca records. *Geochem. Geophys. Geosyst.* 14, 1435–1453.

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